

AGENCY REVIEW DRAFT
RISK ASSESSMENT
ORDOT LANDFILL SITE

GUAM

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US02698

Preliminary Endangerment Assessment for the

Ordot Landfill

Guam

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EXECUTIVE SUMMARY

The Ordot Landfill is a 47-acre municipal landfill located on the Island of Guam. The landfill has been in use since during World War II when it began operations as a depository for military refuse. No records are available regarding the disposal of hazardous waste at the site. Guam selected the Ordot Landfill as its top priority site during the initial selection of sites for the National Priorities List in 1982, due to the potential presence of hazardous waste in the landfill and potential release of contaminants to the Guam's drinking water aquifer and the Lonfit River adjacent to the site.

As part of the remedial action at CERCLA (Superfund) sites, a baseline assessment of the potential risks to public health, welfare or the environment posed by the site is required. This document presents such an assessment (Endangerment Assessment) for the Ordot Landfill in Guam. The Endangerment Assessment (EA) evaluates the potential risk of harm to humans and the environment using known geographic, demographic, physicochemical and biological information relevant to the site. An EA is performed to evaluate the ramifications of the no-action remedial alternative and to determine if an actual or threatened release of hazardous substances from the site "may present an imminent or substantial endangerment to public health or welfare or the environment" (USEPA 1986). In this context, "imminent" does not necessarily refer to immediate harm but rather to an impending risk of harm (USEPA 1985c). Similarly, "endangerment" means potential as well as actual harm.

Concentrations of contaminants in surface water and groundwater considered in this assessment were obtained from sampling performed by Camp Dresser and McKee (CDM) in 1987. Soil sample results from previous sampling efforts by Black and Veatch (1983) were evaluated in a qualitative manner. Since less than a complete data base was available for this analysis, the EA is presented in a qualitative manner and it should be considered a qualitative preliminary (Level I) Endangerment Assessment. The quantity of empirical data available for this EA is limited. Only 13 surface water and groundwater samples are available for inclusion in this report; no soil or air data are available for

quantitative evaluation. Although, Black and Veatch Associates collected soil samples in 1982, these soil sample results cannot be quantitatively evaluated due to lack of background data.

During the initial site characterization by CDM, a geologic reconnaissance was conducted to determine the geologic characteristics of the site and to evaluate the potential interconnection of the groundwater beneath the site with Guam's primary drinking water aquifer north of the site. Results of this reconnaissance supported previous investigations which reported that the site is hydraulically discontinuous from the northern aquifer.

This EA identifies the characteristics of the site and the surrounding locality, determines chemicals of potential concern at the site, presents the physicochemical and toxicological properties of these chemicals, discusses potential exposure pathways, and provides a comparison of chemical concentrations in groundwater to available standards or health criteria and a qualitative assessment of potential endangerment to public health, welfare or the environment.

Chemicals of concern at the Ordot Landfill site include aluminum, barium, iron, manganese, vanadium and zinc. These chemicals have been detected in both groundwater and surface water. These metals are common soil constituents in the region. However, these metals cannot be discounted as of concern because concentrations downgradient from the site are elevated above concentrations measured at an upgradient location. High concentrations of these metals were also found in leachate samples from the landfill, but not in the major surface water body, the Lonfit River. Additional chemicals of concern are found solely in leachate. Chromium, cobalt, copper, cyanide, lead and potassium may have future impacts as a result of potential releases to the Lonfit River.

In assessing the risks posed by contaminants at a site, it is necessary to consider the potential toxic effects and potency of the individual chemicals. Aluminum at high doses has been associated with neurological disorders. At high doses, barium has been associated with high blood pressure in laboratory

animals. Chronic iron poisoning at high doses over various exposure routes can result in gastrointestinal bleeding, pneumonitis, convulsions and hepatic toxicity. Chronic exposure to high levels of manganese is associated with a progressive neurological disease. High doses of zinc can lead to anemia. At the levels found on site, these effects are not expected to result from human exposure to contaminated media.

Potential human exposure pathways at the Ordot Landfill include exposure to contaminated groundwater via ingestion and exposure via direct contact with landfill leachate. Under current conditions, exposure to contaminated groundwater is unlikely because the contamination is limited to an aquifer beneath the site which is artificially saturated. It is not used as a drinking water source nor for any other purposes. A separate aquifer provides drinking water for the whole island. This aquifer does not appear to be contaminated and is hydrogeologically isolated from the contaminated aquifer.

Under the Superfund Amendments and Reauthorization Act of 1986 (SARA), levels of contaminants present in environmental media at a site must be compared to applicable or relevant and appropriate requirements (ARARs). ARARs are federal and/or state criteria or standards that are deemed either applicable or relevant to the particular situation. Potential chemical-specific ARARs are available for eight of the chemicals of concern for the Ordot landfill site; no chemical-specific ARARs are available for aluminum, cobalt, potassium or vanadium. The potential ARARs for barium, chromium, cyanide and lead are primary Maximum Contaminant Levels (MCLs) drinking water standards that are based on health-related effects. Potential ARARs for copper, iron, manganese and zinc are secondary Maximum Contaminant Levels (SMCLs) which are not derived from health-based criteria. The concentrations of barium, and zinc measured in groundwater and in leachate do not exceed potential ARARs. Concentrations of iron and manganese exceed their respective MCLs; however, the concentrations of these chemicals are low and are unlikely to pose a significant public health risk. Concentrations of chromium, copper, cyanide and lead in leachate do not exceed potential ARARs.

Numerous species of vegetation and wildlife are found in the vicinity of the Ordot Landfill site. A federally endangered bird species, the Guam Gallinule, was identified in the area; no other federally endangered species were identified. There is no indication that vegetation and wildlife populations are adversely affected by the presence of site-related containments. However, a quantitative resource damage assessment has not been conducted.

The assessment of risks at any site is subject to a number of uncertainties. These uncertainties are associated with data collection, exposure assessment, the evaluation of toxic potency and final risk characterization. At this site, all environmental media were not sampled; and of those media sampled, few samples were collected. Surface water sample techniques may be responsible for the absence of volatile organics in the samples. Flow measurements of the leachate stream and the Lonfit River were not collected; so the dilution effects of the river could not be calculated.

1.0 INTRODUCTION

This report constitutes a preliminary assessment of health risks for the Ordot Landfill site located on the Island of Guam, a United States Territory. This assessment is qualitative in nature and is based on the limited groundwater and surface water sampling results reported in the Initial Site Characterization Report prepared by Camp Dresser and McKee, Inc. (1987). An endangerment assessment (EA) is prepared as part of the evaluation of a site subject to clean-up action under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980 as amended in 1986 under the Superfund Amendments and Reauthorization Act (SARA). An EA is performed to evaluate the ramifications of the no-action remedial alternative and to determine if an actual or threatened release of a hazardous substance from the site "may present an imminent or substantial endangerment to public health or welfare or the environment" (EPA 1986).

EPA defines three levels of detail for endangerment assessments. This preliminary EA represents a Level I effort, or qualitative, assessment. As a Level I EA, this document characterizes the physical description of the site and identifies contaminants detected or suspected to be at the site. The toxic properties of the identified contaminants are discussed and exposure pathways of potential concern are analyzed based on site investigation sampling results. Based on the potential for exposure and the toxic properties of the chemicals of concern, a preliminary assessment is made of whether the site presents an imminent or substantial endangerment.

In Section 2 of this assessment, the Ordot Landfill site is described and the history of the site is summarized, the nature and extent of chemical contamination at the site is characterized, the demographic and environmental characteristics are described, and the contaminants considered most likely to pose a health risk (the chemicals of concern) are identified. Section 3 discusses the environmental transport and fate of the chemicals of concern and also summarizes the toxic properties of the contaminants from a human health standpoint. A preliminary exposure assessment, including a discussion of possible exposure pathways and a description of potential receptors is

presented in Section 4. The preliminary risk assessment and environmental assessment are presented in Section 5. Conclusions of this endangerment assessment are presented in Section 6.

2.0 SITE CHARACTERIZATION

2.1 SITE DESCRIPTION AND HISTORY

Ordot Landfill is located near the village of Ordot on the island of Guam in the Mariana Island chain in the Western Pacific (Figure 2-1). The Ordot Landfill began operations during World War II as a depository for military refuse first by the Japanese military and then by the United States (CDM 1987). From the time the military discontinued use until the late 1960s, the 47 acre site was used as an open dump receiving non-military wastes from the island (Black and Veatch 1983). Since the late 1960s, Guam's Department of Public Works has operated the site as a sanitary landfill. Since 1981, military wastes have been shipped off the island. The exact dates of operation and details concerning the transition in ownership are unavailable. No records exist regarding the types of waste disposed at the site or their volumes. Potential sources of wastes include an oil refinery, aircraft maintenance shops and a hospital. Under current practices, the landfill is covered with dirt occasionally to control odor and the spread of debris from the landfill. The site is currently not in compliance with an administrative order under the Clean Water Act to prevent discharge of leachate to the Lonfit River. At the time of a site visit by CDM and ICF/Clement personnel in March 1987, the landfill was fenced, but was easily accessible to trespassers.

2.2 ENVIRONMENTAL CHARACTERISTICS OF THE SITE

The potential impacts of contaminants at any site depend in part on ecological and demographic characteristics. Contaminant migration off site is influenced by local meteorology, topography and surface drainage, hydrogeology and mineralogy as well as other site characteristics. These are summarized briefly below for the Ordot Landfill.

2.2.1 METEOROLOGY

There are distinct wet and dry seasons in Guam. The dry season runs from January to June with average precipitation of 5 inches per month. The

typhoon season marks the beginning of the wet season which runs from July to December with average rainfall of 10 to 15 inches per month. The wet season runs from July to December and marks the beginning of the typhoon season. The average annual rainfall in Guam is about 95 inches (CDM 1982). The average annual temperature on the island of Guam is 81°F (Tracey et al. 1964). Prevailing winds in the area are easterly, though wind reversal does occur during the wet season (CDM 1982).

2.2.2 TOPOGRAPHY AND SURFACE DRAINAGE

The Ordot Landfill is located in the volcanic upland region near the center of the island at an elevation of 200 feet (Figure 2-2). There is a suspected fault north of the site known as the Adelup fault which separates the southern volcanic portion of the island and the northern limestone plateau (Tracey et al. 1964). It is north of the northeastern boundary of the site (Black and Veatch 1983). Soil at the landfill is composed of very fine grain volcanic sediments with a high clay content and low permeability (CDM 1987).

The landfill is located in a basin between two ridges; surface water runoff consolidates near the northeastern boundary of the landfill and flows into and beneath the landfill. Runoff exits at various points throughout the landfill. A major portion of this water flows into the Lonfit River south of the site. This river merges with the Sigua River to form the Pago River, which ultimately drains into Pago Bay on the east side of the island. A leachate swamp is located on the northeastern corner of the landfill. During the rainy season, leachate is produced at numerous locations throughout the landfill and is known to pond on the southern end of the site (CDM 1987). Perennial leachate streams discharge to the Lonfit River (CDM 1987).

There are no upgradient surface waters in the volcanic region around the Ordot Landfill. The Geus River in Merizo, and Fena Lake are the only sources of potable water in the volcanic southern region of Guam (Guam EPA 1988).

2.2.3 HYDROGEOLOGY

Groundwater underlying the site is encountered at approximately 28-60 feet below ground surface (bgs). This aquifer results from surface water migration through the fill material and it does not penetrate the underlying volcanic bedrock (CDM 1987). Monitoring wells in the vicinity of the landfill do not produce water readily and were bailed dry during sample collection (CDM 1987). Groundwater in the volcanic region of the island is not used for municipal or domestic purposes (CDM 1987). Drinking water for the volcanic region is obtained from groundwater from the northern portion of the island and from surface water upgradient from the site.

To the north of the landfill is a deposit of limestone up to 600 feet thick. This deposit absorbs rainwater and forms the major water-bearing unit for the island of Guam known as the Agana sub-basin of the Northern Lens Aquifer. Groundwater in the Agana sub-basin near the northern portion of the site is encountered between 120 and 330 feet bgs. Wells in the Agana sub-basin were included in the remedial investigation to ascertain the possible influence of the landfill on local drinking water. No interconnections were discovered between the aquifer located in the volcanic region beneath the landfill and the limestone water-bearing unit of the Agana sub-basin (CDM 1987).

2.2.4 MINERALOGY

The volcanic rocks of Guam range in type from basalt and olivine basalt to andesite, with more than 50 percent mafic andesite. Minerals present in the volcanic rocks are plagioclase feldspars and pyroxenes; olivine and quartz are present but not abundant. As the parent material of soils, the mafic rocks on Guam are generally altered to clays with weathering frequently occurring to 100 feet bgs. Clay in the area is acidic (pH = 5.3) which may facilitate the leaching of metals during the rainy season. Soils in the volcanic region of the island contain large amounts of aluminum oxide (27-42 percent), free iron oxide (15 percent) and manganese oxide (0.24 percent) (Carroll and Hathaway 1964).

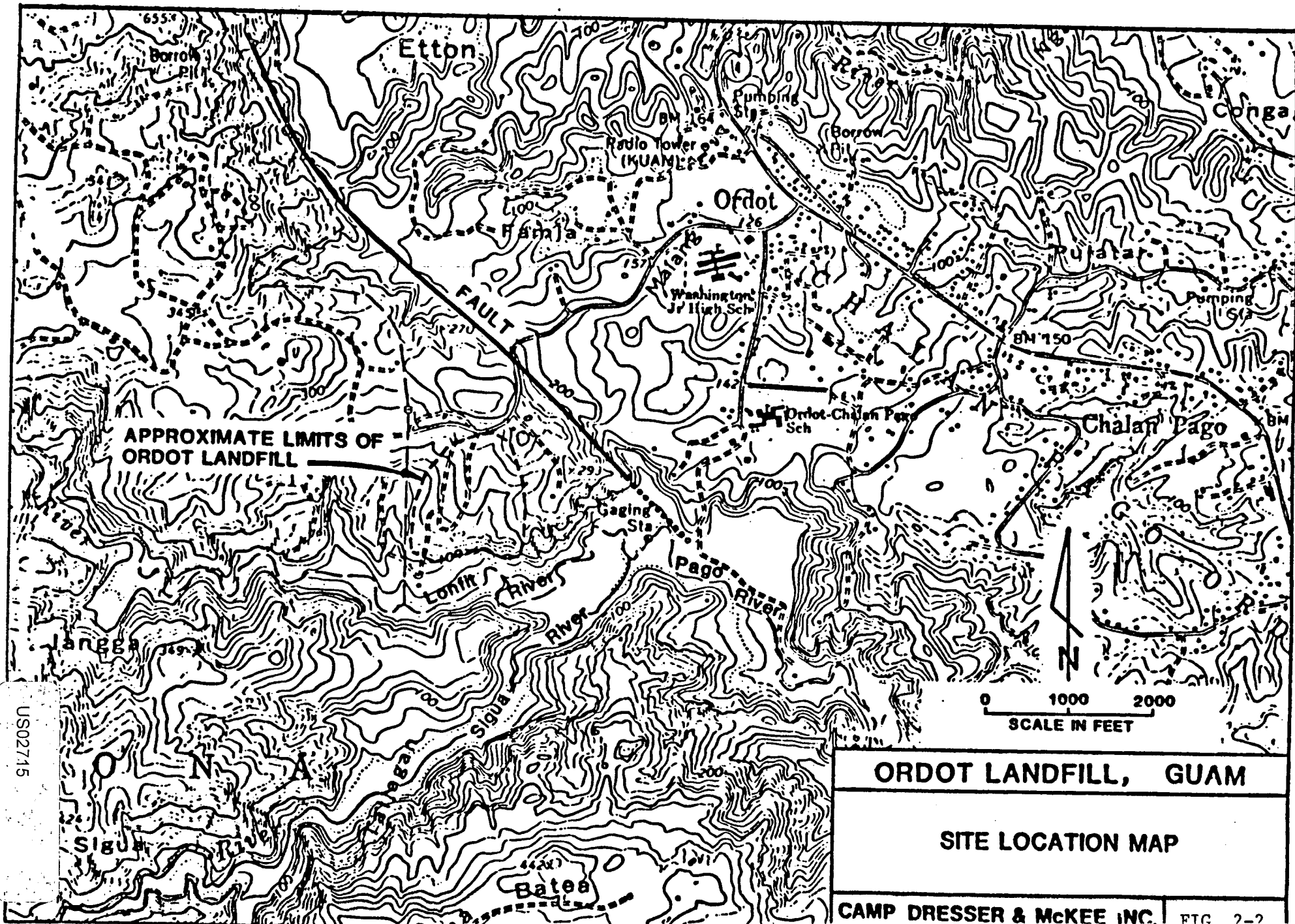
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ORDOT LANDFILL, GUAM

LOCATION OF ORDOT LANDFILL -ISLAND OF GUAM

CAMP DRESSER & MCKEE INC.

FIG. 2-1



ORDOT LANDFILL, GUAM

SITE LOCATION MAP

CAMP DRESSER & McKEE INC. | **ETC 2-2**

2.2.5 ECOLOGICAL CHARACTERISTICS

A variety of wildlife lives at or near the landfill. Mammals present in the area include non-native deer and pigs. Among the birds residing at or near the landfill are black francolans, golden livers and Guam Gallinules, a federally-listed endangered species. Toads, gekkos and snails are also found at the landfill. Aquatic species found in the Lonfit River include gobis, small mouth bass, prawns and mollusks and fresh water eels (CDM 1987). Jungle vegetation surrounds the landfill; bananas and vegetables are grown on land adjacent to the landfill. Vegetation is especially lush near leachate streams (Black and Veatch 1983).

2.2.6 SITE DEMOGRAPHICS

The Ordot Landfill is located within the municipality of Ordot-Chalan Pago approximately 2 1/2 miles south of the town of Agana and approximately 1 mile west from the town of Ordot. The nearest residences and a school are located approximately 1/4 mile east of the site.

2.3 NATURE AND EXTENT OF CONTAMINATION

During the March 1987 site investigation by CDM, a total of 13 surface water and groundwater samples were collected; these samples were analyzed and validated by EPA's Contract Laboratory Program (CLP). Of these 13 samples, seven were collected to characterize area groundwater and six were collected to characterize on-site leachate and off-site surface water conditions. As an initial site screening, water samples were analyzed for the entire suite of Hazardous Substance List (HSL, now known as Target Compound List) chemicals to provide baseline chemical characteristics of the landfill. Soil samples were not collected during the March 1987 investigation. During the period of on-site sample collection, real-time ambient air monitoring (using direct reading instruments) was conducted to evaluate the need for quantitative air sample collection. No volatile compounds other than methane were detected during this monitoring effort and no quantitative air samples were collected (CDM 1987); the air sampling effort will be discussed further in Section 2.3.4.

Other sampling investigations have been performed at the Ordot Landfill. In 1982, during a multiple island hazardous waste site assessment program, Black and Veatch Associates collected soil and water samples from the site. Black and Veatch collected six on-site surface soil samples, groundwater samples from the municipal wells in the Agana sub-basin, and surface water samples from the Lonfit River and on-site leachate. This site assessment program considered in this EA as a secondary source of data and the results will be discussed in a qualitative manner only.

2.3.1 GROUNDWATER

The groundwater data presented in this preliminary EA were obtained from samples collected by CDM in March 1987; also discussed are the Black and Veatch sampling results from the municipal wells in the Agana sub-basin. Well depth information was presented in the CDM investigation report (CDM 1987).

A total of seven groundwater samples were collected from five wells. Three of these wells were installed around the landfill by the University of Guam's Water and Energy Research Institute (WERI) in 1986 (Guam EPA 1988). Two wells, GW #5 and GW #6, are downgradient of the landfill. The WERI upgradient well, GW #4, is in the same water bearing unit as the downgradient wells. Figure 2-3 illustrates the on-site well sample locations. Samples from two municipal wells were collected to assess off-site conditions. Figure 2-4 presents the location of these two wells (wells A-11 and A-12). These municipal wells are located in the Agana sub-basin which is geologically isolated from the groundwater underlying the site.

All samples were analyzed for metals, cyanide, volatile and semivolatile organics and organochlorine pesticides using standard CLP analytical protocols. Groundwater sample results for metals are presented in Table 2-1 for the WERI on-site wells and in Table 2-2 for the Agana sub-basin. Metals detected in groundwater include aluminum, barium, calcium, iron, magnesium, manganese, nickel, sodium, vanadium and zinc. With the exception of nickel,

these chemicals were found in both upgradient and downgradient wells. Nickel was detected in only one downgradient sample. Downgradient sample results revealed elevated concentrations of all contaminants except sodium. Volatile organics were not detected at concentrations above the detection limits. No pesticides, cyanide or other semivolatiles were detected in any of the samples.

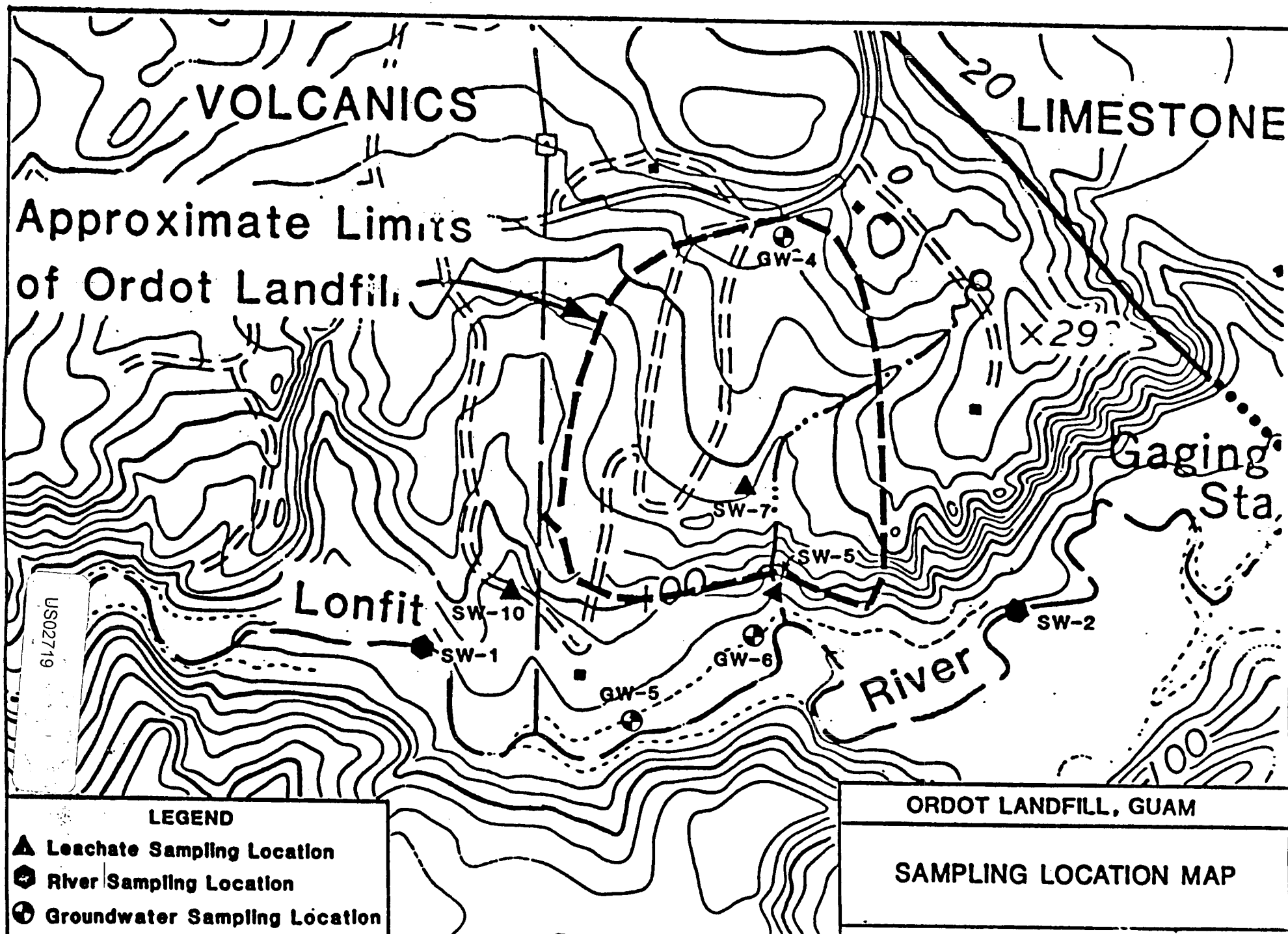
The 1987 groundwater data presented in Table 2-1 may not represent the actual concentrations of contaminants in groundwater beneath the landfill because the wells were potentially contaminated during the drilling process. Water from the on-site leachate pond was used in drilling the wells (CDM 1988) and as a result of this drilling method, samples from these wells may have higher concentrations of potential contaminants than the underlying groundwater. In the 1987 sampling of these wells, the wells were bailed dry and allowed to recharge prior to sample collection as specified in CDM's sampling plan (CDM 1988).

During the sampling by Black and Veatch in 1982, only the Agana sub-basin wells were sampled. Nickel was detected in both wells in the Agana sub-basin; other contamination was not detected in the two wells sampled which is consistent with the CDM results.

2.3.2 SURFACE WATER and LEACHATE

Six surface water samples were collected by CDM in March 1987. Of these six samples, two samples were collected from the Lonfit River at upstream and downstream locations from the landfill. A duplicate sample was collected at the downstream location. The exact distance from the landfill were not recorded. Three leachate discharge points were sampled as well. Sediment samples were not collected. Sample locations are indicated on Figure 2-3.

All samples were analyzed for metals, cyanides, volatile and semivolatile organics and organochlorine pesticides using standard EPA protocols. Sample results from the analyses for metals are presented in Table 2-3. Contaminants



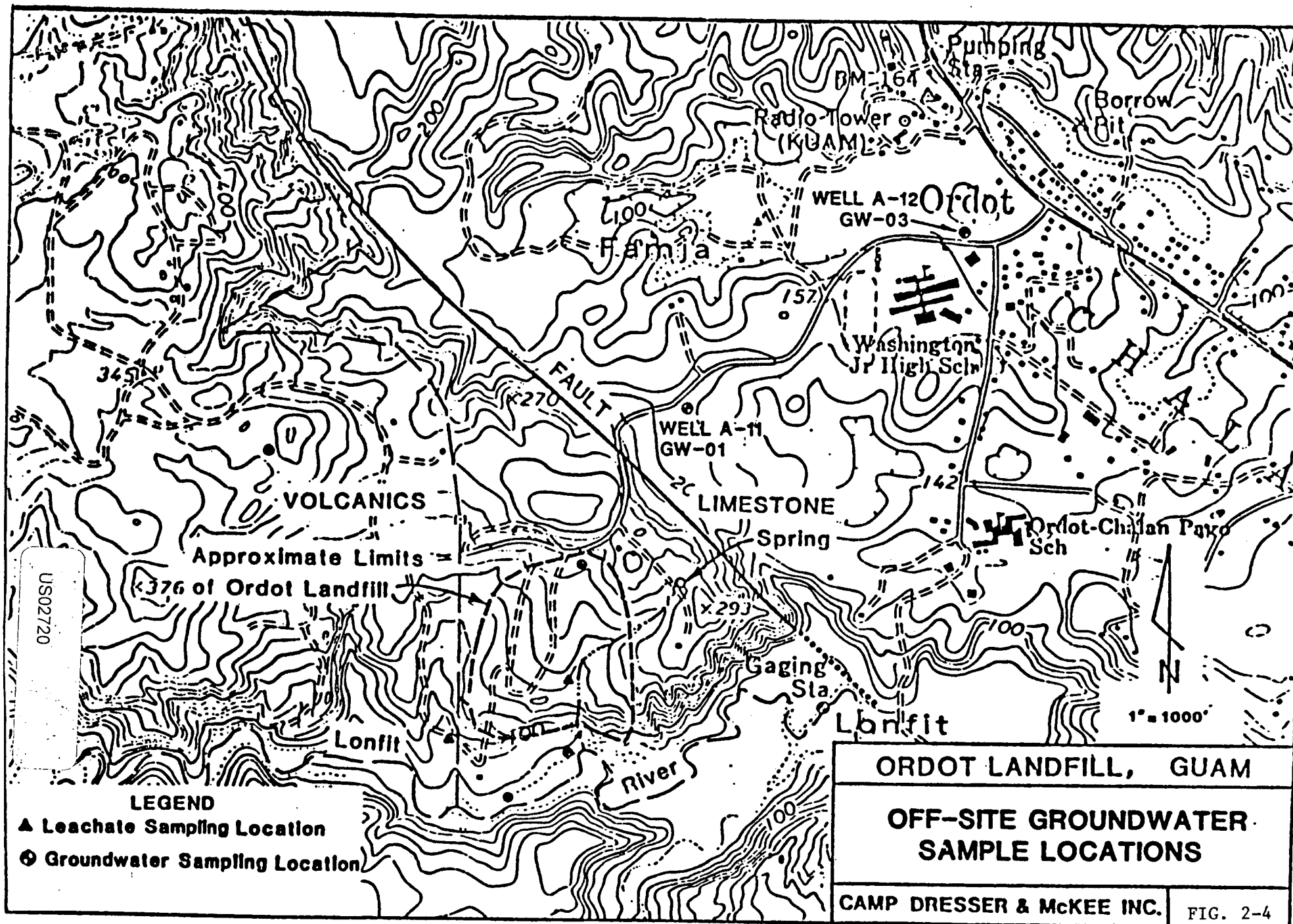


TABLE 2-1
CONCENTRATIONS OF INORGANICS DETECTED IN
GROUNDWATER BENEATH THE ORDOT LANDFILL
SAMPLES COLLECTED MARCH 1987

CHEMICAL	WERI BACKGROUND WELL	WERI DOWNGRAIENT WELLS		
	CONCENTRATION (ug/L)	FREQUENCY OF DETECTION	GEOMETRIC MEAN CONC. (ug/L)	MAXIMUM CONC. (ug/L)
ALUMINUM	7	2/2	845	854
BARIUM	9	2/2	50	190
CALCIUM	53930	2/2	60155	86965
IRON	124	2/2	776	954
MAGNESIUM	7491	2/2	43473	60555
MANGANESE	8	2/2	89	92
NICKEL	ND ^a	1/2	32	32
SODIUM	12880	2/2	9723	63970
VANADIUM	ND	2/2	4.9	6.6
ZINC	20	2/2	142	148

^aND = Not Detected; the detection limit for nickel is 23 ug/L.

TABLE 2-2
CONCENTRATIONS OF METALS DETECTED IN
GROUNDWATER FROM THE AGANA SUB-BASIN
NORTH OF ORDOT LANDFILL
SAMPLES COLLECTED MARCH 1987

CHEMICAL	FREQUENCY OF DETECTION	GEOMETRIC MEAN CONC (ug/L)	MAXIMUM CONC (ug/L)
ALUMINUM	2/2	45	46
BARIUM	2/2	5.5	6
CALCIUM	2/2	115,537	117,300
IRON	2/2	61	65
MAGNESIUM	2/2	3642	4126
MANGANESE	2/2	2	4
NICKEL	0/2	ND ^a	ND
SODIUM	2/2	9801	11,076
VANADIUM	0/2	ND	ND
ZINC	2/2	44	45

^aND = Not Detected

found in surface water samples from the Lonfit River are aluminum, barium, calcium, iron, magnesium, manganese, sodium and zinc. With the exception of iron, magnesium, sodium and zinc, all chemicals were found in higher concentrations in upstream samples. The Lonfit River sample concentrations did not differ significantly between upstream and downstream locations. In addition to the chemicals found in the Lonfit River, chromium, cobalt, copper, cyanide and lead were found in on-site leachate. Volatile and semivolatile organics and organochlorine pesticides were not detected in the Lonfit River or in leachate samples; these will not be discussed further.

During the Black & Veatch sampling effort conducted during the rainy season, barium, iron, manganese, boron and mercury were found in Lonfit River samples. Additional analytes found solely in landfill leachate include aluminum, copper and lead (Black & Veatch 1983).

2.3.3 SOIL

Soil samples were not collected during the remedial investigation conducted by CDM in 1987 at the Ordot Landfill. Previous to the site evaluation, Black and Veatch (1983) performed a site investigation at the Ordot Landfill. Surface soil samples were collected from the landfill; background soil samples were not collected. Sample results revealed the presence of phthalates and metals on site. Phthalates are used in the production of plastics and are found at most landfills. The metals found in these soil samples are intrinsic to the volcanic region of Guam and because no background samples were collected, the source of these metals cannot be determined.

TABLE 2-3
CONCENTRATIONS OF METALS DETECTED IN
SURFACE WATER AND LEACHATE SAMPLES FROM THE ORDOT LANDFILL
SAMPLES COLLECTED MARCH 1987

CHEMICAL	<u>LONFIT RIVER</u>		<u>LEACHATE SAMPLES^a</u>		
	UPSTREAM CONCENTRATION (ug/L)	DOWNSTREAM CONCENTRATION (ug/L)	FREQUENCY OF DETECTION	GEOMETRIC MEAN CONC (ug/L)	MAXIMUM CONCENTRATION (ug/L)
ALUMINUM	80	72	3/3	630	3583
BARIUM	5	4	3/3	123	307
CALCIUM	42150	42650	3/3	8348	103700
CHROMIUM	(3.7) ^b	ND ^c	1/3	11	11
COBALT	(6.8)	ND	1/3	13	13
COPPER	(5.9)	ND	1/3	31	31
CYANIDE	(10.0)	ND	1/3	19	19
IRON	106	171	3/3	1817	39260
LEAD	(5.0)	ND	2/3	10	18
MAGNESIUM	8745	9188	3/3	42576	60290
MANGANESE	20	4.5	3/3	465	3161
POTASSIUM	(948)	ND	3/3	17315	126600
SODIUM	17890	19110	3/3	112096	126600
VANADIUM	5.4	3.8	1/3	12	12
ZINC	9	14	3/3	27	73

^aLeachate samples were collected from sample locations SW-05, SW-07, SW-10. See Figure 2-2.

^b() = Analyte not detected; detection limit shown in parenthesis.

^cND = Not Detected.

2.3.4 AIR

During the March 1987 sampling round, a site screening air survey was conducted using portable instruments (i.e., HNu, OVA, radiation meter, oxygen meter, particulate monitor) to analyze for methane, volatile organics, oxygen (to determine the presence of oxygen-deficient or oxygen-rich atmosphere), particulates, hydrogen sulfide and radiation. With the exception of low levels of methane gas, similar to levels found at many landfills, no chemicals were present at detectable concentrations (CDM 1987). Based on these results, further ambient air samples were not collected at the landfill.

2.4 PRELIMINARY SELECTION OF CHEMICALS OF CONCERN

As noted in the preceding sections, a number of inorganic compounds have been detected in surface and ground waters at the Ordot Landfill Site; organic compounds have rarely been detected. As part of a site-specific risk assessment where many chemicals have been detected, a subset of key chemicals of concern is selected in order to focus the assessment. The selection of the chemicals of concern for the Ordot landfill in this preliminary EA is based on groundwater and surface water sample results because no quantitative data for other environmental media were available for evaluation.

One of the primary criteria used for selecting chemicals for evaluation at any site is a comparison of on-site concentrations to background concentrations. In general, chemicals at concentrations that are less than twice background are believed to be attributable to natural variation in background and are not considered to be chemicals of concern. In groundwater at the Ordot Landfill, the concentrations of calcium and sodium detected in the WERI downgradient wells are less than twice the concentration detected in the background well and, therefore, they will not be considered further. Aluminum, barium, iron, magnesium, manganese, nickel, vanadium and zinc were all present in downgradient wells at concentrations that were more than twice background and could be selected as chemicals of concern based on this criterion.

Selection of chemicals of concern may also include consideration of the known use or presence of a compound at a site, the magnitude of detected concentrations and the known toxic potential of a compound. For example, chemicals not known to have been used at the site or that are clearly not of toxicological concern may be removed from further consideration even if they are present at elevated concentrations when compared to background. Of the compounds present in groundwater at elevated concentrations, aluminum, barium, iron, manganese, vanadium and zinc are known constituents of munitions and municipal refuse; therefore they will be considered chemicals of interest for the site. Magnesium is commonly found as natural soil constituents of Western Pacific islands such as Guam (Tracey et al 1964) and is relatively non-toxic; therefore, magnesium will not be discussed further. Nickel was detected in one downgradient well but not in the other downgradient well or the background well. Since it also was not detected in landfill leachate samples, nickel is not likely to be a site-related contaminant and will not be considered as a containment of concern.

In addition to the inorganics identified in the groundwater and surface water, several chemicals were detected in on-site leachate. Chromium, cobalt, copper, cyanide, lead and potassium were detected in on-site leachate but were not found in the groundwater or surface water. Sampling efforts during both the wet and dry seasons did not indicate the presence of chromium, copper, cyanide, lead and potassium in the Lonfit River or other surface water and, therefore unlikely that these contaminants are influencing off-site media.

Leachate is currently unavailable for use by humans; it is not known if wildlife utilize the leachate pond on-site for nesting or feeding. At this time, it is unlikely that the contaminants found in leachate pose a public health risk; however, in the future, the impact to the Lonfit River of the site may change suddenly (i.e., landslide) and a threat to public health may occur. Another potential route of human exposure include ingestion of potentially contaminated wildlife (e.g. pigs) which may frequent the ponds. At this time, no data exist to evaluate this pathway. For this reason and the limited amount of sample data available, chromium, cobalt, copper, cyanide, lead and potassium will also be considered contaminants of concern for this EA.

TABLE 2-4
CHEMICALS OF CONCERN
ORDOT LANDFILL

CHEMICAL	MEDIUM	FREQUENCY OF DETECTION	GEOMETRIC MEAN (ug/L)	MAXIMUM CONCENTRATION ^a (ug/L)
ALUMINUM	surface water	1/1	72	72
	groundwater	2/2	845	854
	leachate	3/3	630	3583
BARIUM	surface water	1/1	4	4
	groundwater	2/2	50	190
	leachate	3/3	123	307
CHROMIUM	surface water	0/1	ND ^b	ND
	groundwater	0/2	ND	ND
	leachate	1/3	11	11
COBALT	surface water	0/1	ND	ND
	groundwater	0/2	ND	ND
	leachate	1/3	13	13
COPPER	surface water	0/1	ND	ND
	groundwater	0/2	ND	ND
	leachate	1/3	31	31
CYANIDE	surface water	0/1	ND	ND
	groundwater	0/2	ND	ND
	leachate	1/3	19	19
IRON	surface water	1/1	171	171
	groundwater	2/2	776	954
	leachate	3/3	1817	39,260
LEAD	surface water	0/1	ND	ND
	groundwater	0/2	ND	ND
	leachate	2/3	10	18
MANGANESE	surface water	1/1	4.5	4.5
	groundwater	2/2	89	92
	leachate	3/3	465	3,161
POTASSIUM	surface water	0/1	ND	ND
	groundwater	0/2	ND	ND
	leachate	3/3	17,315	126,600

TABLE 2-4
(Continued)

CHEMICALS OF CONCERN
ORDOT LANDFILL

CHEMICAL	MEDIUM	FREQUENCY OF DETECTION	GEOMETRIC MEAN (ug/L)	MAXIMUM CONCENTRATION ^a (ug/L)
VANADIUM	surface water	1/1	3.8	3.8
	groundwater	2/2	4.9	6.6
	leachate	1/3	12	12
ZINC	surface water	1/1	14	14
	groundwater	2/2	142	148
	leachate	3/3	27	73

^aSurface water maximum corresponds to concentrations detected at the downstream sample location.

^bND = not detected.

3.0 CHARACTERISTICS OF CHEMICALS OF CONCERN

This section contains information on the fate and transport properties of the chemicals of concern. Also provided in this section is key information regarding the toxicity of the contaminants. The selection of the chemicals of concern was based on 13 samples taken from surface and ground waters on and around the site. No soil data or air data were available to contribute to the selection process.

3.1 FATE AND TRANSPORT PROPERTIES

The relevant physicochemical properties of the chemicals of concern detected at the Ordot site are discussed in this section. These properties influence chemical fate and transport processes in the environment. The mobility and persistence of site contaminants depend upon the properties of the contaminants and the properties of the local environmental media.

3.1.1 ALUMINUM

Aluminum, a major constituent of clay, is one of the most commonly occurring elements in the earth's crust (Considine 1983). Clay sorbs aluminum very tightly because aluminum is a natural constituent of the clay lattice (Marshall 1964). Under low pH conditions, aluminum is soluble and mobile in most environments (Brown 1986).

3.1.2 BARIUM

Barium can form compounds with acetate, nitrate, chloride, and hydroxide, but these compounds are very soluble. In soils containing these compounds, barium's mobility is increased (EPA 1985). Barium is likely to stay in solution in the absence of adsorptive carbonate or clays (EPA 1984b). Barium has not been found to form complex ions in water (Cotton and Wilkinson, 1972).

3.1.3 CHROMIUM

Chromium (Cr) can be found in oxidation states ranging from -2 to +6. Cr III is the most commonly occurring oxidation state, and Cr VI is the next most frequently encountered. Cr V and Cr IV are unstable intermediates that occur during the reduction of Cr VI to Cr III. The lower oxidation states are only formed under strongly reducing conditions, and of these oxidation states, only Cr II is found in aqueous solutions (Cotton and Wilkinson 1972; Moore and Ramamoorthy 1984).

Cr III is the predominant form under the pH and redox conditions commonly found in natural waters and soils. Cr III tends to form stable complexes with both organic and inorganic anions, and those anions should remove Cr III from solution. Most of the Cr III found in soils is in mixed Cr III and Fe III oxides or in the lattice of minerals, although Cr III complexed with organic ligands may stay in solution for over a year (James and Bartlett 1983a). Cr III is mobilized only in a very acidic soil media. The adsorption of chromium onto clays is pH-dependent.

3.1.4 COBALT

Cobalt generally occurs in the 0 or +2 oxidation states. Elemental Cobalt is relatively unrelative and is quite stable in air or water. Cobalt appears to occur rarely in soluble form in natural aquatic systems. Several surveys show that cobalt frequently is not detectable and that concentrations greater than 10 ug/liter are rare (NAS 1977). The most important control or mobility of cobalt in aquatic and terrestrial systems is probably absorption to the clay minerals and hydrous oxides of iron, manganese, and aluminum that are often present in the clay fractions of sediments and soils. Small amounts of cobalt may be solubilized by bacteriological activity. Cobalt is an essential element and can be accumulated by plants and animals, through generally not too excessive concentrations (NAS 1977). Atmospheric transport of cobalt and cobalt compounds can occur.

3.1.5 COPPER

Copper (Cu) can be found in three oxidation states: 0, +1 and +2. Of these three, only the +2 oxidation state is found in aquatic systems. In polluted environments, copper can also form complexes with cyanide, amino acids, and humic substances. In the absence of organic complexing agents, hydrolysis and precipitation dominate copper's chemistry in aqueous environments.

The interactions of copper with organic materials in natural waters have been studied extensively. Organo-copper interactions result in the increased solubility of some copper-containing minerals and the subsequent transport of the organocupric complex (Ong et al. 1970; Rashid and Leonard 1973). Hydrous metal oxides can sorb copper and render it immobile (Jenne 1968). This sorption process is competitive with other metals present and could result in the release of copper. Copper is not very mobile in sediments. Adsorption, precipitation, and organic complexation are also important processes in soils (Kabata-Pendias and Pendias 1984). These processes render copper one of the least mobile metals.

3.1.6 CYANIDE

The behavior of cyanide (CN) compounds in soils has not been widely studied. The fate and transport of cyanides will depend upon their form. The simplest cyanide, hydrogen cyanide (HCN), is an acid and can dissociate into the cyanide ion (CN⁻). HCN and CN⁻ are jointly referred to as free cyanide.

The simple cyanides are comprised of HCN and those salts formed with Group I and Group II metals, such as NaCN and Ca(CN)₂. These rapidly dissociate in water, leaving CN⁻ to hydrolyze or to react with trace metals. Iron, gold, cadmium, copper, nickel, silver, and zinc have also been found to form simple metalocyanides (Fuller 1977, 1978). Simple metalocyanides have solubilities ranging from essentially insoluble (copper and nickel) to highly soluble (barium and potassium).

3.1.7 IRON

Iron is a relatively immobile element. Biological and chemical reactions cause precipitation of iron in soils, which accounts for its immobility. Fe(II) is more soluble than the Fe(III) form, and hence, more mobile in soils, though it was found that Fe(II) from landfill leachate migrated "surprisingly slowly under highly acidic conditions (Fuller 1978). In aquatic media, iron can undergo many different chemical reactions which depend on pH and oxidation-reduction potential. It was found that greater than 82 percent of dissolved iron is chelated with dissolved organic carbon ligands (Steinburg, 1980).

3.1.8 Lead

Lead (Pb) is found in the +2 and +4 oxidation states. The most commonly found ion in the environment is Pb^{+2} . Metallic lead can be formed under reducing or basic conditions when very little sulfur is present (Cotton and Wilkinson 1972). The predominant fate of lead in the environment is sorption to soils and sediments. Carey et al. (1980) found lead concentrated in the surface soils. The adsorption of lead is pH dependent, increasing with increasing pH. Above pH 7, essentially all lead in soil is sorbed (Huang et al. 1977). Korte et al. (1976) found that lead was virtually immobile in all but sandy soils.

There is some disagreement about the precise distribution of lead in aquatic systems (EPA 1979). However, it is generally agreed that lead concentrations in water decrease over time and that sorption of lead to both sediments and dissolved particulates is the favored process, with clay, hydrous metal oxides, and organic matter influencing this process. The presence of the clays and oxides will enhance the sorption of lead to the soils. Organic matter will react with the lead to form an organo-lead complex, which then will probably sorb to soil particles. Lead sorption increases over the pH range of approximately 5-8, and above pH 6, it becomes the dominant process.

3.1.9 MANGANESE

Manganese can occur in all valence states from -3 to +7. Mn(II) is very common and forms many salts. The solubility of manganese depends upon the pH of the aquatic environment. Mn(III) and Mn(IV) are only slightly soluble, though under neutral pH conditions these species may be reduced to Mn(II) which is more soluble and more mobile. Manganese can be chelated by a variety of organic and inorganic ligands. These ligands tend to keep manganese in solution. The soluble fraction of manganese ranges from 15-95 percent of the total, and is not dependent on pH, alkalinity, specific conductivity or concentration of humic substances in water (Laxen et al., 1984). Soil-bound manganese can be dissolved by organic acids (Pohlman and McCall 1986).

3.1.10 POTASSIUM

Potassium is the seventh most abundant metal and makes up about 2.4 percent by weight of the earth's crust. Potassium generally occurs in the +1 oxidation state. Potassium is commonly found as potassium chloride and in aluminosilicates complexes (Weast 1976).

3.1.11 VANADIUM

The environmental chemistry of vanadium is very complex. Vanadium can be found in solution in four different oxidation states: V(II), V(III), V(IV), and V(V). V(II) is not commonly found in aquatic or soil systems. Vanadium is relatively mobile in neutral and alkaline soils. V(V) is more soluble and more mobile than V(IV) or V(III) (Vinogradov 1959). A major factor in controlling vanadium's mobility is pH. Vanadium tends to precipitate at higher pH levels.

3.1.12 ZINC

Soil type and the presence of metal oxides influence the mobility of zinc in the soil. In aquatic systems, zinc can form precipitates. Zinc also forms complexes with humic and fulvic acids, which can increase its solubility (Ong

et al. 1970, Rashid and Leonard 1973). It was found that these complexes may keep zinc bound but dissolved to a pH as low as 3. Zinc can be sorbed by hydrous metal oxides, clays, and organic matter. One study showed that iron oxides and phosphates removed zinc from river water (Honba et al. 1983).

3.2 TOXICITY OF CHEMICALS OF CONCERN

A brief description of the toxicity of and the key regulatory criteria for the chemicals of concern are presented in this section.

3.2.1 ALUMINUM

Aluminum is generally considered to be nontoxic (NAS 1982). However, a number of studies have demonstrated neurotoxicity of aluminum in laboratory animals. The role aluminum plays in neurological disorders, including Alzheimer's disease, is not clear. Aluminum has not shown strong carcinogenic or genotoxic potential in animals. The National Academy of Science has advised a Suggested No Adverse Response Level (SNARL) for daily exposure to aluminum via drinking water of 35 mg/L/day (NAS 1984).

3.2.2 BARIUM

The only adverse effect identified in either rats or mice orally exposed to barium in drinking water was a significant increase in blood pressure in rats (EPA 1984b). No increase in blood pressure was seen in humans exposed to elevated concentrations of barium in drinking water in one epidemiological study (EPA 1984b). Toxic effects due to ingestion of some barium compounds include gastroenteritis, muscular paralysis, hypertension and cardiotoxicity (Perry et al., 1983). Data regarding the carcinogenic potential of barium are limited. One study reported no increase in tumor incidence in either rats or mice exposed to 5 mg/liter barium acetate in drinking water through the lifespan (EPA 1984b). Barium has been classified in Group D--Not Classified on the basis of the weight of the evidence for carcinogenicity in humans by EPA's Environmental Criteria and Assessment Office (EPA 1984b). A drinking

water standard maximum contaminant level (MCL) for barium has been set at 1 mg/liter by EPA (1976). An oral RfD for barium of 0.05 mg/kg/day has been determined by EPA (1987a), based on a study by Perry et al. (1983).

3.2.3 CHROMIUM

The toxicity of chromium is dependent to a great degree on the chemical species. Certain chromium (VI) compounds are considered to be carcinogenic by inhalation (but not by ingestion) and chromium (III) compounds are not considered to be very toxic by any exposure route. Studies in humans and animals using a variety of routes of administration have indicated that soluble chromium (VI) and chromium (III) compounds can produce kidney and liver damage following acute exposure to relatively high doses. From the evidence available from both human case reports and animal studies, it is uncertain whether the kidneys and liver may be target organs following chronic exposure. EPA has verified an oral risk reference dose (RfD) for chromium (III) of 1 mg/kg/day and has calculated an allowable chronic oral intake of 5 ug/kg/day for chromium (VI). These values are based on studies in which no adverse health effects were produced in rats exposed to chromium compounds in the diet (Ivankovic & Preussman 1975) or drinking water (MacKenzie et al. 1958). EPA promulgated an MCL of 50 ug/liter for chromium (VI) but has recently proposed an MCLG of 120 ug/liter for total chromium.

3.2.4 COBALT

Cobalt is an essential trace element for humans. Chronic oral exposure to cobalt in high doses can cause goiter, decreased thyroid function, increased heart and respiratory rates and blood lipid changes (Hammond and Beliles 1980). Cobalt salts included in a beer formulation at concentrations 1.2 to 1.5 mg/liter were reported to be responsible for a number of deaths due to congestive heart failure (NAS 1977). No health-based standards exist for cobalt.

3.2.5 COPPER

Copper is not a potent toxic agent to humans (EPA 1980b, 1984f). The current EPA secondary drinking water standard is 1 mg/liter, based on the organoleptic properties of copper rather than on its toxicity (EPA 1980b). The EPA Office of Drinking Water has proposed an MCLG for copper of 1.3 mg/liter based on the occurrence of gastrointestinal effects in man (EPA 1985b, 1984f). EPA has determined oral allowable chronic intake (AIC) of 3.7×10^{-2} mg/kg/day. The oral AIC is based on the lowest-observed adverse effect level in humans.

3.2.6 CYANIDE

Hydrogen cyanide and its simple salts, such as sodium cyanide, are acutely toxic to almost all forms of life by all exposure routes (EPA 1980c). Cyanide has not been tested for carcinogenicity in animals. EPA derived an oral RfD of 0.02 mg/kg/day for cyanide based on a study in which rats were fed cyanide-containing diets for 104 weeks (Howard & Hanzal 1955).

3.2.7 IRON

Iron is an essential element, necessary for the formation of hemoglobin (EPA 1984c) and therefore, more attention has been given to iron deficiency than to iron toxicity. However, chronic iron poisoning can occur from accumulation in body tissues, and causes gastrointestinal bleeding, pneumonitis, metabolic acidosis, convulsions, and hepatic toxicity (EPA 1984c). There is some evidence that high concentrations of certain soluble iron salts may be teratogenic (Hammond and Beliles, 1980). Also, certain iron compounds have been reported to have some genotoxic potential (EPA 1984c). A secondary MCL of 300 ug/liter for iron in drinking water has been set by EPA based on its organoleptic properties and not on health based criteria (EPA 1986d).

3.2.8 MANGANESE

Manganese is an essential trace element. Chronic exposure to manganese is also associated with a progressive neurological disease, known as manganism, which is similar to Parkinson's disease (EPA 1984a). One case study reported manganism associated with extremely high levels of manganese in a drinking water well (Kawamura et al., 1941). Certain manganese compounds have demonstrated genotoxic potential in a variety of test systems (EPA 1984a,d). In laboratory rodents, retardation of reproductive development and reduced fertility have been reported as a result of a manganese deficiency (EPA 1984a). The EPA Office of Environmental Criteria and Assessment has placed manganese in Group D--Not Classified for carcinogenic potential (EPA 1984a). EPA (1984a) has established an acceptable level for chronic intake for the oral route of 2.2×10^{-1} mg/kg/day in which animals exposed to drinking water containing 1 mg/L manganese exhibited no adverse effects. A secondary MCL of 50 ug/liter manganese has been established by EPA (1984a) on the basis of its organoleptic properties.

3.2.9 LEAD

Lead, at relatively low exposure levels, has been shown to cause adverse neurological effects in humans, especially young children and fetuses. Of particular concern are the effects on learning ability that have been associated with very low (e.g., 10-20 ug/dl) blood lead levels (Bellinger et al. 1987). The Centers for Disease Control (CDC) currently define "lead toxicity" in a child as a blood lead level greater than 25 ug/dl and an erythrocyte protoporphyrin level greater than 35 ug/dl (CDC 1985). Oral ingestion of some lead salts has been associated with increased renal tumor frequencies in rats. EPA has classified lead as a Probable Human Carcinogen (Group B2) based on these results. EPA has also noted that the available data provide an insufficient basis on which to regulate carcinogenic lead salts and no quantitative estimate of the excess cancer risk has not been provided. EPA has established an MCL for drinking water of 50 ug/liter. This standard is currently undergoing review by EPA and the EPA Office of Drinking Water has proposed an MCLG of 20 ug/liter for lead. An RfD of 6×10^{-4} can be derived

based on the Office of Drinking Water analysis used to support the proposed MCLG. The analysis focuses on the effects of lead in infants and pregnant women.

3.2.10 POTASSIUM

Potassium is an essential element, and concern is generally focused on potassium deficiency than with the toxicity. The National Research Council of the National Academy of Sciences (NRC 1980) estimated the adequate and safe intake level of potassium to be between 1,875 and 5,600 mg/kg for adults. NRC (1980) also noted that "it is not possible to induce potassium toxicity by dietary means in people with normal circulatory and renal function." No health based standards exist for potassium.

3.2.11 VANADIUM

Short and long-term effects of vanadium exposure due to inhalation principally involve respiratory tract irritation, including coughing, wheezing, breathing difficulties, bronchitis, and chest pains. Eye irritation, skin irritation and tongue discolorations have also been reported (NIOSH 1977, NAS 1974). No data were found regarding the genotoxic potential or reproductive toxicity of vanadium. There is no evidence that vanadium has carcinogenic potential (NIOSH 1977). An oral reference dose (RfD) of 5.7×10^{-3} mg/kg/day for ingestion exposure to vanadium (not otherwise specified) was derived by EPA (1987b).

3.2.12 ZINC

Zinc is not highly toxic to humans and is, in fact, an essential element (EPA 1984e). Oral absorption of zinc is controlled by homeostatic mechanisms and influenced by dietary levels of other nutrients. Zinc salts of strong acids are astringent and corrosive. It has not been reported to be carcinogenic in man or animals. An oral RfD of 0.21 mg/kg/day was derived by EPA (1984e) based on the occurrence of anemia and reduced blood copper in some patients receiving high doses of approximately 150 mg/day zinc (therapeutically) for

extended periods of time. A secondary MCL of 5000 ug/liter has been set by EPA (1984e).

4.0 POTENTIAL EXPOSURE PATHWAYS

In this section, potential exposure pathways are identified and evaluated. An exposure pathway is defined by four elements: (1) A source and mechanism of chemical release to the environment; (2) An environmental transport medium (e.g., air, groundwater) for the released chemical; (3) A point of potential human or environmental contact with the contaminated medium (referred to as an exposure point); and (4) A human or environmental exposure route (e.g., inhalation or ingestion) at the contact point. In this section, possible exposure pathways are discussed and potential receptors for contaminants are identified.

4.1 GROUNDWATER

One of the purposes of the CDM site investigation was to establish whether the limestone aquifer, which supplies drinking water to the northern part of the island, is being impacted by the landfill. As a result of this investigation and previous investigations, it appears that the landfill is not hydraulically connected with the limestone aquifer and does not impact groundwater quality in the Agana sub-basin (CDM 1987, Black and Veatch 1983).

Exposure to contaminated groundwater may occur via several pathways. Of primary concern is direct ingestion of metals in drinking water, as this exposure pathway commonly leads to the greatest amount of exposure. At the present time, there are no known wells used for domestic or other purposes downgradient of the site. The wells from which the WERI data were collected were placed in the artificially saturated landfill material and are not used for public or private water supply. For this reason, human exposure to contaminated well water is not expected. In addition, the aquifer is a low production aquifer; there are no municipal wells in the immediate area to which the chemicals may migrate.

4.2 SURFACE WATER

Potential routes of exposure via surface water include consumption of contaminated fish and ingestion of water from the Lonfit River. Since the contaminants of interest are inorganic compounds, exposure via direct contact from activities such as swimming or bathing is unlikely because these compounds are poorly absorbed through intact skin. Indirect routes for human exposure include watering of vegetables and livestock with contaminated surface water and ingestion of potentially contaminated wildlife (e.g., pigs) and subsequent consumption of contaminants via uptake in food.

Metals of concern found in surface water samples from the Lonfit River include barium, iron, manganese, and zinc. However, the concentrations of chemicals are similar in both upstream and downstream samples from the Lonfit River and, therefore, it is uncertain if their presence is attributable to the site.

Release of landfill leachate into the Lonfit River is a potential future exposure pathway to humans and wildlife, both via direct contact and ingestion of contaminated biota. Since flow measurements of the leachate stream and Lonfit River were not collected, the anticipated dilution of the leachate by the river cannot be determined.

4.3 SOIL

Direct contact with contaminated soil can lead to exposure via inadvertent or intentional soil ingestion or via dermal absorption. The metals of concern for the site are poorly absorbed through intact skin when present in an inorganic form and thus dermal absorption is expected to be insignificant relative to gastrointestinal absorption for these compounds. Contaminated soil on the site can also act as a medium of transport. In general, contaminants can become airborne due to wind dispersion or vehicular dust generation. They may also leach or percolate into groundwater or be transported into local surface water bodies by overland runoff. At this time, potential exposures to contaminated soil cannot be fully evaluated because of the lack of relevant soil concentration data.

4.4 AIR

Exposure to airborne contaminants is most commonly via inhalation. Individuals potentially exposed to airborne site contaminants include on-site workers as well as trespassers and scavengers at the landfill. Alternate routes of exposure include off-site deposition of airborne contaminants and subsequent exposure to contaminated soil or surface water.

During the initial on-site air screening, no on-site emissions except methane were detected. Therefore, off-site emissions are not anticipated. Although the direct reading instruments are sensitive to contamination in the low part per million range, quantitative air sampling has not been performed to address off-site emissions from the landfill. At this time, quantitative data do not exist to evaluate fully potential air exposure pathways.

5.0 PRELIMINARY RISK ASSESSMENT

In this section, information on the potential for exposure to site contaminants is compared with available Applicable or Relevant and Appropriate Requirements (ARARs) or other health-based criteria to get a preliminary estimate of possible risks posed by the site to human health. Comparison of chemical concentrations found at or near a site with ARARs is recommended in EPA guidelines for preparing endangerment assessments. Potential ARARs include Safe Drinking Water Act maximum contaminant levels (MCLs), federal ambient water quality criteria (AWQC), national ambient air quality standards (NAAQS), and state standards.

From the site evaluation activities conducted at the Ordot Landfill, groundwater data for the aquifer beneath the landfill, provided the only future-use values indicative of migration of on-site contamination. These are used in this section for the comparison to ARARs. Although contaminated groundwater is not used for drinking or other purposes, these data were compared to drinking water standards (primary and secondary MCLs) to provide the most conservative estimate of risk.

Leachate contamination may potentially impact either surface water or ground water and therefore, these contaminants will be evaluated for potential human consumption. Because no dilution factors are available and to provide the most conservative estimate of risk to leachate contaminant concentrations for chromium, copper, cyanide and lead will be compared directly to potential ARARs. For those compounds detected in groundwater as well as leachate, groundwater concentrations will be used for comparison to potential ARARs.

The following subsections present the comparison of chemical concentrations in environmental media found at the Ordot Landfill site with potential ARARs. In addition, a qualitative discussion of the potential impacts of site-related contaminants on wildlife and the environment and a discussion of the uncertainties associated with the overall preliminary risk assessment are presented.

5.1 COMPARISON WITH STANDARDS AND CRITERIA

5.1.1 GROUNDWATER

Of the contaminants detected in groundwater at the Ordot Site, ARARs are currently available for barium, iron, manganese, and zinc. There are no potential ARARs for vanadium or aluminum. The ARAR for barium is a primary MCL that is based on health-related effects, while the ARARs for iron, manganese and zinc are secondary MCLs established on the basis of non-health based effects such as objectionable taste and odor. Concentrations of these contaminants detected downgradient of the site during the March 1987 sampling are compared to ARARs to determine the potential for the site to pose a risk to public health or welfare.

Table 5-1 presents a comparison of potential ARARs to the mean and maximum concentrations of contaminants detected in groundwater samples collected downgradient of the site. Background concentrations of barium (9 ug/L), iron (124 ug/L), manganese (8 ug/L) and zinc (20 ug/L) are all below the potential ARARs. The mean value of 49.7 ug/liter for barium is 1/20 of the MCL, and the maximum value of 190 ug/liter is 1/5 of the MCL. The geometric mean for zinc of 142 ug/liter fell far below the MCL level of 5000 ug/liter, as did the maximum concentration of 148 ug/liter.

Since no health-based criteria are available for iron, manganese, vanadium and aluminum, concentrations will be compared to average ingestion assumptions. Groundwater consumption in the area will be assumed to be the United States daily average of 2 L/day for 70-kg adults, even though individuals in the tropics may consume significantly greater quantities.

Iron was detected at a mean concentration of 776 ug/liter in downgradient wells. This value is over twice the secondary MCL for iron (300 ug/liter). However, the MCL for iron is a secondary MCL based on non-health related effects including its staining properties. Were a 70 kg human to consume 3.5 liters of water per day for a 70 year lifetime containing the mean concentration level of iron found in groundwater, the intake would be about

TABLE 5-1
COMPARISON OF CONTAMINANT CONCENTRATIONS
IN GROUNDWATER WITH POTENTIAL ARARs

Compound	Geometric Mean ^a Conc (ug/L)	Maximum Conc (ug/L)	Potential ARAR (ug/L)	Source
Barium	49.7	190	1000	MCL ^b
Iron	776	954	300	SMCL ^c
Manganese	89	92	50	SMCL ^c
Zinc	142	148	5000	SMCL ^c

^a Values from downgradient wells.

^b Primary MCL derived from health-based and technology-based criteria.

^c Secondary MCL based on organoleptic effects and not health-based criteria.

ten times below the USDA Recommended Daily Allowance (RDA) of 10-18 mg/day (NAS 1980). Based on this minimum value as a conservative allowable daily intake for chronic iron exposure, iron is unlikely to pose a public health threat.

Manganese concentrations in groundwater were estimated to be 89 ug/liter, which is higher than the 50 ug/liter secondary MCL set by EPA on the basis of its organoleptic effects and the staining of laundry (EPA 1986d). Using health-based criteria, EPA has established an acceptable level for chronic oral intake of manganese of 2.2×10^{-1} mg/kg/day (1984a). The human intake from drinking 2 liters of water containing the mean concentration of manganese in groundwater (0.18 mg/day) is almost two orders of magnitude below this value for a 70 kg adult, suggesting that manganese does not appear to pose a public health threat.

No ARARs exist for vanadium, however EPA has established a risk reference dose (RfD) of 5.7×10^{-3} mg/kg/day for vanadium. Daily consumption by individuals 2 liters of water contaminated with the mean concentration of vanadium for a lifetime of 70 years by a 70 kilogram individual, would provide a daily intake that is approximately 1.4×10^{-4} mg/kg/day, forty (40) times less than the RfD.

No ARARs exist for aluminum, however the National Academy of Science (1982) has developed a Suggested No Adverse Response Level (SNARL) for aluminum in drinking water of 35 mg/L/day. The concentration of aluminum in all groundwater and surface water samples collected does not exceed this value; therefore, aluminum contamination at the site is unlikely to pose a public health risk.

5.1.2 LEACHATE

For the contaminants found solely in leachate, chromium, cobalt, copper, cyanide, potassium and lead; potential ARARs exist for chromium, copper, cyanide and lead. The ARARs for chromium, cyanide and lead are primary MCLs based on health-related effects, while the ARAR for copper is a secondary MCL based on copper's organoleptic properties. No ARARs exist for cobalt or

potassium. Table 5.2 presents a comparison of potential ARARs to the mean and maximum concentrations of contaminants detected in leachate samples. All leachate contaminant concentrations are significantly below their respective MCLs. Even if leachate from the site were consumed, these chemicals are unlikely to pose a public health threat.

No potential ARARs exist for cobalt or potassium and EPA has established no health-based criteria. However, the National Academy of Science (NAS) believes cobalt in drinking water is not a problem due to its low water solubility in comparison to the maximum No-Observed-Adverse-Effect-Level (NOAEL) of cobalt (doses greater than 1 mg/kg body weight; NAS 1978). The cobalt concentrations on site do not appear to pose a public health threat.

Potassium is an essential element for humans; the estimated adequate and safe intake of potassium for adults is 1875-5600 mg/day (NAS 1980). If a 70-kg adult were to consume 2 liters of leachate per day, the total daily consumption of potassium is unlikely to exceed 4 mg/day using the maximum potassium concentration of 126,600 ug/L. It is therefore, unlikely that potassium would pose a public health threat.

For contaminants found in both leachate and groundwater, ARARs exist for barium, iron, manganese and zinc. As with groundwater, barium and zinc concentrations in leachate do not exceed the potential ARARs. Iron concentrations exceed the SMCL of 300 ug/L; however, if a 70-kg adult were to consume 2 liters/day of the mean concentration of iron in leachate (1,817 ug/L), the RDA for iron will not be exceeded. Manganese concentrations in leachate exceed the SMCL; however, ingestion by a 70-kg individual of 2 L/day of leachate containing mean concentration of manganese in leachate (465 ug/L) would create a daily intake of 1×10^{-2} mg/kg/day which is approximately an order of magnitude lower than the RfD. Similar calculations for vanadium indicate that consumption of leachate would be in order to magnitude below the RfD. Aluminum concentrations do not achieve the SNARL and therefore do not appear to pose a public health risk.

TABLE 5-2

COMPARISON OF CONTAMINANT CONCENTRATIONS
IN LEACHATE WITH POTENTIAL ARARs

Compound	Geometric Mean Conc. (ug/L)	Maximum Concentration (ug/L)	Potential ARAR (ug/L)	Source
Chromium (total)	11	11	170	MCL ^a
(III)			50	MCL
(VI)			170	MCL
Copper	31	31	1000	SMCL ^b
Cyanide	19	19	200	MCL
Lead	10	18	50	MCL

^aPrimary MCL derived from health-based and technology-based criteria.

^bSecondary MCL based on organoleptic properties.

Although contaminants found in leachate exceed some potential ARARs, none of the contaminants exceed health-based criteria. In the unlikely event that leachate were to be consumed, no public health threat is anticipated.

5.2 PRELIMINARY ENVIRONMENTAL ASSESSMENT

Environmental conditions and characteristics were not discussed in CDM's Initial Site Characterization Report (CDM 1987). Therefore only limited information was available for the preparation of this section which is based primarily on the field notes of ICF/Clement personnel who visited the site in March 1987. As part of this preliminary EA, a qualitative evaluation of the environmental impacts of the site is presented below.

Algal blooms and fish kills have been reported in Pago Bay downstream from the landfill but the cause has not been identified (Black and Veatch 1983). None of the Lonfit River samples exceed Ambient Water Quality Criteria (AWQC) values for the protection of both marine and freshwater aquatic life. Future impacts of landfill leachate to the Lonfit River and subsequently to Pago Bay cannot be quantitatively evaluated. However, leachate contaminant concentrations can be compared to the AWQC values for freshwater aquatic life.

AWQC values exist for chromium, copper, cyanide, iron, lead and zinc. If all chromium found in on-site leachate is considered to be hexavalent then landfill leachate is equal to the freshwater chronic criterion (11 ug/L) for hexavalent chromium; since trivalent chromium is the more prevalent ionic species in aquatic systems, it is unlikely that the AWQC values are exceeded. The copper concentrations exceed both the acute (22 ug/L) and chronic (5.2 ug/L) criteria for freshwater aquatic systems; however, due to copper's physicochemical properties which cause it to absorb into sediments, it is unlikely that the copper from the leachate will be found in surface water. The cyanide level exceeds the AWQC for freshwater aquatic species for chronic exposure. The mean concentration of iron (1817 ug/L) in landfill leachate samples exceeds the chronic freshwater AWQC for iron of 1000 ug/L. The mean lead levels in leachate exceed the chronic AWQC (5.2 ug/L) for freshwater

chronic exposure. As with copper, lead is likely to absorb to sediments and not be present in surface waters. The maximum concentration of zinc (73 ug/L) in landfill leachate exceeds the AWQC for zinc of 47 ug/L for protection of freshwater aquatic life.

Based on the comparison to AWQCs, if leachate were to discharge directly into the Lonfit River without dilution then an environmental impact may be anticipated. Since the leachate samples were collected on the landfill and not at discharge points to the river where dilution would be a significant factor, the overall impact of these concentrations on aquatic life in the river is not known. Additionally, the AWQCs are primarily based on aquatic species found in or near the mainland United States. Potential impacts on tropical aquatic species are unknown.

5.3 UNCERTAINTIES IN THE ENDANGERMENT ASSESSMENT FOR HUMAN HEALTH

The procedures and inputs used to assess potential human health risks in this evaluation are subject to a number of uncertainties. These are best summarized as stemming from four main sources:

- environmental chemistry sampling and analysis,
- environmental parameter measurements,
- toxicological data and dose-response extrapolations, and
- errors through combinations of the above.

The primary source of uncertainty in this preliminary assessment stems from the limited sampling that has occurred. At the Ordot Landfill, a small number of water samples were collected and analyzed to determine the extent of the contamination and no soil samples were collected and analyzed as part of the most recent site investigation. Of five groundwater wells sampled, only two wells were downgradient of the landfill and therefore likely to provide information on site-related contamination. Since few samples were collected, the samples used to characterize the site may not be representative of actual on-site conditions. The absence of volatiles in surface water samples may be indicative of sample collection techniques and not site conditions. The air data reviewed for this assessment did not indicate the presence of

contamination. However, only a few data were available for evaluation, potential sources of on-site contamination may not have been adequately characterized, thereby limiting the extent of this assessment. Some contaminants found solely in leachate were detected in only one sample; use of a single discrete sample location to characterize the overall impact of the site may greatly overestimate the potential risk from the site. Additionally many compounds often associated with munitions waste (eg. nitrate, perchlorate) were not analyzed for.

A second source of uncertainty results from the toxicological studies that are often used to predict the potential health effects of a chemical in humans and which may serve as the basis for the ARARs and other health-based criteria developed by EPA. Extrapolation of toxicological data from animal tests is one of the largest sources of uncertainty in risk assessment. There may be important but unidentified differences in uptake, metabolism, and distribution of chemicals in the body between the test species and man. Typically, animals are administered high doses of a chemical in a standard diet. Humans, on the other hand, may be exposed to much lower doses in a highly variable diet. In these studies, animals, usually laboratory rodents, are exposed daily to the chemical agent for various periods of time up to their 2-year lifetime. Humans have a 70-year lifetime and may be exposed either intermittently or regularly for an exposure period ranging from months to a full lifetime. Because of these differences, it is not surprising that extrapolation error is a large source of uncertainty in risk assessment. Even if studies in humans are available, uncertainties can be large because the diet, activity patterns, exposure duration and frequency, and individual susceptibility may not be the same in the study populations as in the individuals exposed to environmental concentrations.

A third source of uncertainty is the using of the standard United States drinking water consumption rate (2 L/day) for individuals in the tropics. Individuals in the tropics are known to drink greater amounts of water and therefore, use of the 2 L/day estimate may underestimate risk.

TABLE 5-3

Comparison of Chemical Concentrations found in Leachate and Surface Water to Ambient Water Quality Criteria
 Ordot Landfill, Guam

Chemical	--Leachate Concentration--		--Surface Water Concentration--		--Ambient Water Quality Criteria(*)--			
	Geometric Mean (ug/L)	Maximum (ug/L)	Upstream (ug/L)	Downstream (ug/L)	Fresh Acute (ug/L)	Fresh Chronic (ug/L)	Marine Acute (ug/L)	Marine Chronic (ug/L)
Aluminum	630	3,583	80	72	--	--	--	--
Barium	123	307	5	4	--	--	--	1,000
Total Chromium	11	11	ND	ND				
Chromium(VI)					16	11	1,100	50
Chromium(III)					1,700	210	10,300	170
Cobalt	13	13	ND	ND	--	--	--	--
Copper	31	31	ND	ND	18	12	2.9	2.9 (SMCL)
Cyanide	19	19	ND	ND	22	5.2	1	1
Iron	1,817	39,260	106	171	--	1,000	--	300 (SMCL)
Lead	10	18	ND	ND	82	3.2	140	50
Manganese	465	3,161	20	5	--	--	--	50 (SMCL)
Potassium	17,315	126,600	ND	ND	--	--	--	--
Vanadium	12	12	5	4	--	--	--	--
Zinc	27	73	9	14	320	47	170	58
								5,000 (SMCL)

(*) EPA 1986b.

(SMCL) = Secondary Maximum Contaminant Level based on organoleptic effects.

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6.0 CONCLUSIONS

This preliminary risk assessment was conducted to evaluate whether or not contamination at the Ordot Landfill site is likely to pose an imminent and substantial endangerment to public health for individuals in the area. In this context, "imminent" does not necessarily refer to immediate harm but rather to an impending risk of harm (EPA 1985C). Similarly, "endangerment" means potential as well as actual harm.

The Ordot Landfill site is located on the island of Guam, a United States Territory. The landfill is categorized as a municipal landfill, although it has not been fully characterized to determine the presence of hazardous wastes.

Investigations at the site have revealed the presence of aluminum, barium, iron, manganese, vanadium and zinc possibly attributable to military and municipal wastes disposed at the landfill. Inorganic contaminants are present in detectable levels in downgradient groundwater and on-site leachate, but not in naturally-occurring surface water bodies. Aluminum, barium, iron, manganese, vanadium and zinc were selected as potential chemicals of concern for the site based on their presence in groundwater. Persons using groundwater or surface water may be exposed to these chemicals. Chromium, cobalt copper, cyanide, lead and potassium were selected as chemicals of concern for the cited based on their presence in leachate. In groundwater, barium and zinc concentrations do not exceed potential ARARs. Iron and manganese concentrations exceed their respective ARARs; however, as discussed in Section 5, the measured concentrations are unlikely to pose a significant health threat since groundwater is not used for drinking or other purposes. Even if people were to consume contaminated groundwater or leachate, no adverse public health risk is anticipated. No interconnectedness between the aquifer beneath the site and the Guam's primary drinking water aquifer were discovered. None of the chemicals of concern present in surface water are present in concentrations that exceed ARARs or other health-based criteria. The impact of landfill leachate and landfill waste on the Lonfit River has not been demonstrated during the sampling episodes at the Ordot Landfill; however,

an impact may occur during an instantaneous release of contamination from the landfill occurs (eg. landslide). Based on limited available information, the site does not currently appear to pose an imminent health threat,.

Concentrations of contaminants in surface water and groundwater considered in this assessment were obtained from sampling performed by Camp Dresser and McKee (CDM) in 1987. Soil sample results from previous sampling efforts by Black and Veatch were evaluated in a qualitative manner. Since less than a complete data base was available for this analysis, the EA is presented in a qualitative manner and it should be considered a preliminary (Level I) Endangerment Assessment.

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